SIM4SECURITY. A Forecast and Spatial Analysis Model for Homeland Security. Portugal 2030

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Abstract

Demographic studies are a support instrument for decision-making in the field of security policies. Security is a public good, perceived as a critical political issue in the actual context of unstable balance between investment in internal security forces, and urgency of reducing criminality. SIM4SECURITY (PTDC/ATP-DEM/1538/2014) is a technological solution, based on a GIS model and demographic forecasting, which can improve the operational activity of the security forces. We aim to perform demographic disaggregated scenarios in order to optimize the ratio police/citizen, and assure the effectiveness of the security model based on new risks and threats, insecurity factors and the new necessities of local populations. Being a mutable system, the model will be able to monitor up until 2030 and take into account change of parameters, variables and factors that prove to influence dynamic population distributions scenarios.

Keywords**:** Demography; Dynamic and Spatial Clustering; Forecasting Analysis; Homeland Security; Public Policies.

Resumo

Os estudos demográficos são um instrumento de apoio à decisão no âmbito das políticas de segurança. A segurança é um bem público e representa uma questão política que exige a tomada de opções racionais entre investimento nas forças de segurança e a urgência de reduzir a criminalidade e os seus impactos. Como contributo para a resolução desta questão propomos a criação do SIM4SECURITY (PTDC/ATP-DEM/1538/2014), uma solução tecnológica baseada no desenvolvimento de um modelo SIG e na elaboração de cenários demográficos. Os resultados do exercício prospetivo permitirão otimizar a rácio polícia/cidadão e melhorar a eficácia do modelo de segurança, tendo em conta novos riscos e ameaças, novos fatores de insegurança e necessidades específicas adaptados às especificidades locais. O modelo é dinâmico e permite monitorizar até 2030 as mudanças de parâmetros, variáveis e fatores que venham a ser considerados influentes na distribuição da população portuguesa no território.

Palavras-chave**:** Demografia; *Clustering* dinâmico e espacial; Análise prospetiva; Segurança; Políticas Públicas.

1. Introduction

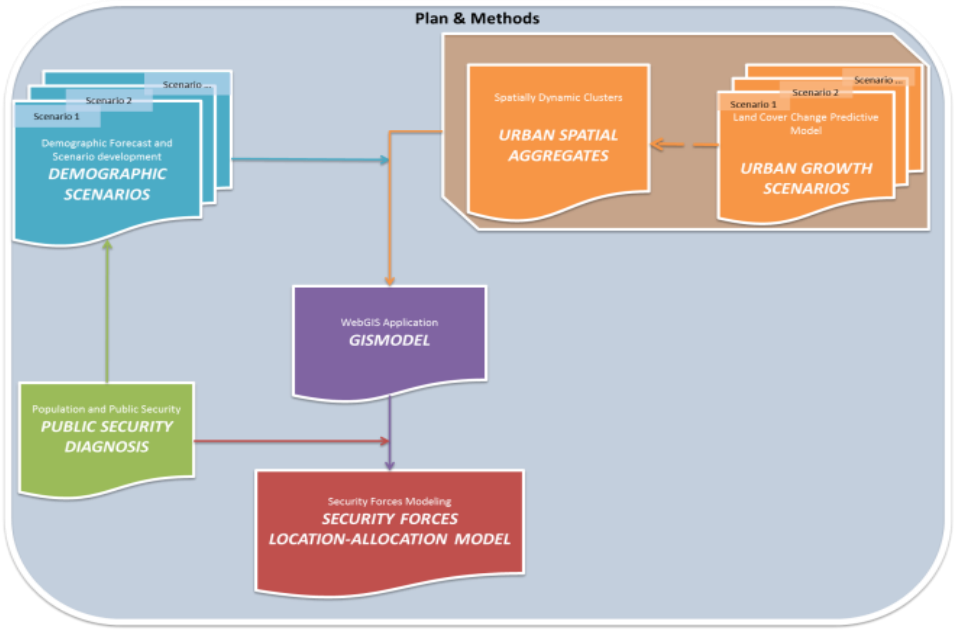
This paper aims to present a scientific tool to support decision making, based on the development of a GIS model and demographic scenarios, which may improve the effectiveness of the operational activity of the security forces, in relation with the Portuguese population. We aim to provide a comprehensive assessment and spatial analysis linking security policies and population needs which has never been performed in Portugal.

In the current model of democratic rule of law, security is assumed as a basic right of citizens, gaining the status of an essential duty required to State. At the same time, budgetary constraints oblige an increasingly careful strategic management, adapted to the reality and endowed with adequate decision support instruments. The SIM4SECURITY simulator will allow policymakers, leaders and forces of command a planning and rational affectation of resources adjusted to local dynamics in crime prevention, combat and suppression of criminality. By performing demographic disaggregated scenarios, it will optimize the ratio police/citizen, allow the evaluation and assessment of the effectiveness of policing model, optimize the resources to affect the security infrastructure building according to geographical realities (rural and urban). Through the intersection of data, resulting from demographic estimates and dynamic tools of spatial analysis, SIM4SECURITY will allow planning the territorial device according to local present and future population needs, the emergence of new risks, of new threats, and insecurity factors. Being an evolutionary system, initially it will be able to monitor up to 2030 and technically capable of development and update up to 2030 (**Figure 1**).

This model will comply a set of rules and procedures, in order to represent and predict a specific outcome, and will solve some location/allocation problems, which stands as one of the great advantages in using predictive models with spatial interaction. Integrated and supported by the WebGIS application, it will allow users to easily simulate, emulate and handle impacts generated by variations in a parameter, variable or factor will provide dynamic population distribution scenarios, visible on a map, aiming to assist planning issues and location/allocation problems related to the internal security sector, such as: 1) suitability of the police offer distribution according to population characteristics; 2) study of risk groups spatial and temporal dynamics and impact assessment in police distribution; 3) deployment of police forces; 4) estimation of security agents for a given area; 5) number and type of

professionals. All of these examples have spatial expression and they will differ according to the developed scenarios.

Figure 1- SIM4SECURITY



Many of these questions have already been answered elsewhere, but not in Portugal, what justifies this application that is based on a design research new in national terms. Overall, our project aims to provide an extensive and comprehensive assessment and spatial analysis of the security sector versus population needs. This 2 years' project will be held by a team composed by researchers with different academic backgrounds and experience on demographic analysis, security, political science, statistics and spatial analysis, and it is structured in five major tasks:

1. *Analysis and diagnosis of the current national situation, regarding population and public security*: a. Population dynamics; b. Security Forces (resources and location); c. Distribution and typology of the security forces giving population characteristics;

2. *Demographic forecast and scenario development, and population risk groups*: a. Population projections (2011-2030) by sex, age and micro simulation of risk groups (according to previously identified criteria of age, sex, national origin, place of residence) scenarios; b. Distribution model of the security forces strength and equipment location;

3. *Development and implementation of a GIS and design of a dynamic geoprocessing model*: a. Development and implementation of a WebGIS application; b. Making available a WebGIS application for mobile devices (smartphones and tablets);

4. I*mplementation of Advanced Spatial Analysis Methods:* spatially dynamic clusters and modeling

land cover change predictive model;

5. *Modeling the distribution of Security Forces*: number of officers and facilities location, according to the developed scenarios.

Main expected outcomes

The institutional architecture of internal security in Portugal is plural (two police forces, a judicial police, a service of foreigners and borders, a marine police and other entities with administrative police functions), which causes conflicts of competence, operational redundancies and duplication of means and resources. The various stakeholders recognize the need to change the current model, in order to assure the convergence of means, resources and operational activity, based on cooperation and information sharing between all participants.

Emerging security threats and risks forces the State to establish an appropriate institutional framework for internal security action and resources allocation (Alves and Valente, 2006; Alves, 2008; Alves, 2009). As new duties are attributed to security actors, population's safety becomes a central issue and demographics a strategic vector (Fernandes, 2005). Despite the problems already identified in Portuguese homeland security system (Teixeira et al., 2006) the analysis and evaluation of decision-making policies about public security resources distribution and needs has never been made in a systematic way. The Police/inhabitants ratio influences citizens' safety but it varies in a nonlinear way with population's volume (Fernandes, 2011; Fonoberava et al., 2010; Teixeira, 2012).

However, public security capabilities are not only human resources. The search for the best optimization of public resources distribution gains importance considering increasingly scarce budgets and the need to maintain standards. Portuguese recent demographic and social changes redraw population distribution (Carrilho and Patrício, 2008), but most of the importance of demographic factor for security policies has to be seen from its endogenous characteristics (sex, age, distribution) which influences collective perceptions in a context of the human security concept (Vaz, et al., 2010).

National strategy in terms of territorial distribution of the two security forces (GNR, PSP) assumes demographic criteria defined in the 90's (Loureiro, 1995). Taking into account: recent demographic dynamics, mostly in terms of volume, mobility and structure and their impact on vulnerable groups, it is urgent to guarantee for the coming decades:

1. The adequacy of the current security forces distribution model and,

2. The possible scenarios linked to demographic trends and the emergence of more plural risk groups (Magalhães and Peixoto, 2008).

Our proposed model aims to assist planning issues and optimize resources:

1. Adequacy of police offer distribution to local residents' characteristics;
2. Study of spatial and temporal dynamics of groups at risk and impact assessment in police offer;
3. Deploying police forces;
4. Number and type of effectives needed for each area.

A comparative study of the solutions found by police in several countries with a similar matrix to Portugal will be held. Portugal has a dual system of security forces, and in the current economic and financial context it needs to make the best use of available public resources. Security forces must know the exact boundaries of their jurisdiction, and have the resources to tackle crime.

The two main problems we consider are: 1) distribution optimization of human resources and infrastructures of the security forces; 2) awareness of the dynamic character of the territorial reorganization of the police forces system, which must follow the change of volume and movement of the urban fabric. As such, we rely on the location of the Security Forces in proximity of the population to be served by the public security service and to be guaranteed the presence of authority, sending to the background the placement of such forces near political and administrative power. We will use an innovative multifactor simulation platform.

The WebGIS application and model will offer special and potentially important means to support planning and decision-making, providing the responsible institutions for public policies within national security sector with the ability of creating scenarios by crossing demographic forecasting with spatially dynamic tools and models. Such model will allow achieving a balanced and optimized distribution throughout the territory of public security forces and facilities according to population evolution. Several studies show that the ratio police/population vary in a non-linear way according to population size. In Portugal there are no studies on this issue. To overcome the current problem, we propose to build an algorithm that optimizes that ratio in order to (i) establish the ratio police/citizen, (ii) build the simulation platform and (iii) estimate the future needs of public safety.

Demographic characteristics always interact in a complex way with internal security system. We aim to cross a set of methodologies, in order to promote a better understanding of

the impact of ageing in next decades, taking into account that age structure will influence the nature of most public policies. Population characteristics change in demographic, social, economic and biological terms. It is therefore relevant to identify these characteristics at national and regional level, offering possible scenarios to decision makers and regional planners about future characteristics of the users of security services. Portuguese population major trends are known. What is new in this case is that we will do demographic projections by sex and age disaggregated by parish (2011-2030), in order to predict microanalysis distribution trends, giving special attention to specific vulnerable groups, such as youngsters and seniors, and cross the output scenarios with wealth local standards and residence vulnerability, according to security classification (Urban Sensitive Areas-ZUS). We will use demographic cohort and survival analysis in order to: (a) identify and characterize Portuguese population dynamics main trends until 2030 (b) consider ageing phenomenon as inevitable and forecast its impact on population's distribution; c) understand and relate these demographic dynamics with socioeconomic changes and wealth micro regional pattern and migratory trends; (d) forecast future changes in demographic structures by age, sex and educational level and the way they will influence security risks and perceptions.

As we said a main component of the model is related with the development of a dynamic database and model supported by a Geographic Information System (GIS). The fusion between Internet and GIS evolved rapidly in the Web 2.0 era, resulting in WebGIS applications and changed the way geospatial information is acquired, transmitted, shared and visualized (Longley et al., 2011). This offers special and potentially important means to support planning and decision-making process, providing the responsible institutions for public security policies with the ability of creating scenarios by using forecasting and spatially dynamic tools and models. This application will solve some location-allocation problems, issues that typically involve where to locate and how to allocate demand for a service (Longley et al., 2011) taking into account several factors (as the number of facilities available, cost, maximum impedance from a facility). This stands as one of the great advantages of using predictive models with spatial interaction. The application aims to create several location-allocation scenarios and population forecasting. Another relevant component is the possibility of projecting high dimensional data into lower dimensional spaces. It will be possible to cluster population forecasting data from parishes into regions and we wish to follow how forecasted population is distributed within each spatial unit and to understand the best method

to spatially aggregate these units, using spatial clustering methods, in order to create police action regions for parishes.

In order to predict future urban populated land use (Cabral and Alexander, 2009), we suggest an integrated approach of remote sensing (to obtain information about urban phenomenon), GIS (the integrating element for all the data and the vehicle for output analysis) and modeling. Urban land use patches generated by remote sensing classification procedures need to be aggregated into meaningful regions for national security. Spatial clustering is one of the most important tasks in data analysis.

Another relevant component to this study is related with the implementation of a Land Use and Cover Change Model (LUCC) to study urban growth, which will enable to create scenarios of future urban growth. LUCC models can be very useful for researchers who want to understand urban growth, for politicians and urban planners as an educational tool to visualize different scenarios of urban change. Currently there are dozens of LUCC models and the criteria to distinguish between them is very diverse: the aggregation level, the use of discrete or continuous mathematics, the type of data, the methods employed in the state of cells definition, the types of outputs, and so on. Developing efforts to compare modelling results is an important topic in the LUCC research agenda. The rapid expansion of urban areas is related to the economic, political and cultural reality of the territory. Urban sprawl generates a chain of problematic issues, which can be prevented with planning and land management strategies. We pretend to cross demographic forecast results along with land use maps forecast. Using this information as input, the goal is to create spatially contiguous or near-contiguous regions using several criteria such as the resident population, socio-economic attributes or total area. This can be also seen as a specific type of clustering where instead of using only a similarity criterion some other criteria are used in the process. This process is usually known as Zone Design (ZD) and it can be defined as the task of grouping a set of basic areal units into a smaller number of zones which are in some sense optimal. This task requires the use of computation and automatic procedures, and can present some optimization problems, that we propose to solve either using Self-Organizing Maps, a particular artificial neural network, or genetic algorithms.

We intend to use a Land Transformation Model (LTM), an LUCC model based on GIS, Artificial Neural Networks (ANN) routines, remote sensing and geospatial analysis tools. LTM provides the dynamic modelling of social, political and environmental factors, such as

the distance to public transportation and road networks, proximity to natural resources such as rivers and lakes, agricultural and forest densities, identification of exclusionary zones and population growth. The ANN are employed in studies about urban growth because they learn about the relationships that exist between urban growth factors and the site attributes. LTM studies demonstrated that dynamic modelling and the scenario prediction are essential to planning and territorial management. Due to LTM land use modelling and forecasting capabilities, we decided to use this model in this study. The urban areas could be obtained from CORINE Land cover (CLC) map of years 2000 and 2006. The LUCC model will use distance to roads, slope and distance to city centers as drivers of urban growth of urban growth.

A demographic forecast and some scenario development will be presented while in the last, forecast maps of land use for the next 10, 20 and 30 years will be produced. We aim to combine these two datasets, allowing a more detailed analysis of the population spatial-temporal. Since the demographic forecast will be aggregated by administrative regions (parish) it assumes that any outputted statistics have a homogenous distribution. To get a higher detailed this is combined with urban versus non- urban maps allowing heterogeneous administrative regions regarding the forecasted variables. The goal is to create spatially contiguous or near-contiguous regions using several criteria such as the resident population, socio-economic attributes or total area. To achieve this goal, we will apply two different approaches. In the first approach an artificial neural network (SOM) will be used to cluster the input data into spatially consistent regions of similar socio-economic attributes. Several restrictions can be added to this optimization analysis, such as the total area or the number of inhabitants per region. The second approach will take advantage of evolutionary computation methods, more specifically Genetic Algorithms (GA) to present several possible regional grouping solutions. GA have been successfully used in optimization tasks and are considered one of the most powerful optimization strategies available. Nevertheless, GA remains unexplored in this field and further research is necessary to develop an appropriate model. The resulting output will be a clustering model capable of creating regions where similar security approaches should be undertaken easing the definition and implementation of policy measures.

Though the creation of an algorithm that establishes the relationship between public security resources and population, and optimizes the distribution of security SIM4SECURITY model will assure: (i) adequacy of the distribution of police resources according to the

characteristics of the population; (ii) spatial dynamic and demographic subgroups prospective scenarios and impact assessment of security forces territorial distribution.

Why should we use predictive and dynamic models? First of all, a model has the capability to support a decision or design process in which a user wishes to find a solution to a spatial problem, perhaps a solution that optimizes some objective, by giving the possibility to experiment on a world replica. Lastly, a model allows users to examine dynamic outcomes by viewing the modeled system as it evolves and responds to inputs (Longley et al., 2011). Scenarios evaluated with dynamic models are thus a very effective way of motivating and supporting debates over policies and decisions.

The GIS application, which will be available in a restricted and secure web application, will be the key interface between users and the model, in which, besides using basic spatial visualization, navigation and spatial tools, will also gave them the freedom to manipulate and change parameters/factors, allowing them to visualize its changes, effects and impacts produced on a dynamic map, aiming to create several scenarios and population forecasting for 2030. It would allow users to dynamically simulate, emulate and handle impacts generated by scenarios and population distribution, aiming to assist planning issues and before-mentioned location-allocation problems, regarding the internal security sector.

With this information, there could be conducted studies that may gave some hints and clues on how to make a better and effective security resources management and allocation, considering the diversity and specificity of each area, crime levels and public perceptions about security.

The integrated and multidisciplinary approach we propose, using quantitative and qualitative methods is innovative and constitutes a valuable tool for decision-making, institutional and educational purposes. To accomplish our goal, we combine several fields and scientific areas, namely, demographic analysis, security, political science, statistics and spatial analysis, using specific methodological approaches and techniques (LUCC mapping and analysis, spatial clustering, modeling).

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